ECONOMIC AND ENVIRONMENTAL ASPECTS ON ENERGY ALTERNATIVES FOR A CLEAN AIR – WIND FARMS

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ABSTRACT. - **Economic and environmental aspects on energy alternatives for a clean air – wind farms**. Wind energy represents an increasingly more attractive alternative in Romania. Regulations concern investment and operation of installations, but also energy recovery and environmental protection. Wind farms development, sustained by landscape, wind speed distribution and investors financial promotion, competes with the prudence imposed by the potential environmental impact (biodiversity, microclimate, etc), and the lack of historical data and information structuring. Adequate organization and dissemination of relevant information might be valuable for investors and sustainable development strategies.

Keywords: "atmosphere protection", "wind energy", "environmental data", and "impact"

1. INTRODUCTION

Fossil fuels combustion in energy sector has a major contribution to the generation of greenhouse gases emissions (GHG) - mainly carbon dioxide. Emissions reduction represents an important mean to protect the environment and to improve the health status of the population - the major requirement in the context of a sustainable development strategy – knowing the association of the greenhouse effect with climate change.

On the other hand, fossil fuels are limited and expensive resources. According to the Romanian National Agency for Mineral Resources (2009), under the current extraction level the national oil and gas resources are industrial exploitable for 15 years, while coal would be available for about 30 years.

At present, the alternative of renewable energy – solar, wind, geothermal, hydro, and biomass - becomes more and more attractive at global scale. The use of renewable energy offers a "clean" alternative for energy production, which allows considerable reductions in emissions of greenhouse gases and also fossil fuel savings.

By ratifying the Kyoto Protocol, Romania has undertaken to reduce in 2008-2012 the GHG emission levels by 8% compared to the level of 1989, its reference year. By the Decision No 406/2009/EC of the European Parliament on the effort of Member States to reduce GHG emissions so as to comply with the

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commitments of the Community for reducing emissions of greenhouse gases until 2020, Romania has a limit for greenhouse gas emissions of +19% compared to the GHG emission levels in 2005.

According with the provisions of 2009/28/EC Directive on the promotion of the use of energy from renewable sources, Romania as Member State has a target allocation, at the level of the year 2020 of 24% share of energy from renewable sources in the gross final consumption, representing a growth of 6.2% compared to the year of reference 2005 (the reference value for 2005 was 17.8%).

2. WIND ENERGY POTENTIAL IN ROMANIA IN TERMS OF RENEWABLE ENERGY USE AND GHG EMISSIONS REDUCTION

2.1 Wind Energy Potential in Romania

Romania's energy strategy has been developed for 2007-2020. The general objective of the strategy for the energy sector is to satisfy the requirements of energy – in the present and for the medium and long term - at a suitable price, for a modern economy and a civilized standard of life, in terms of quality, safety, while complying to the principles of a sustainable development.

One of the priority objectives of Romanian policy for the energy sector is promoting the valorization of renewable energy sources (RES), Romania having a total potential of energy renewable sources evaluated and published since 2003.

Table 1. ***The national technical potential of renewable sources of energy in Romania***

Source	***Annual potential***	***Equivalent energy economy (Thousand toe)***	***Application***
Solar energy	60 x 10^6 GJ 1200 GWh	1433 103.2	Thermal energy Electric power
Energy from wind (theoretic potential)	***23 x 10^3 GWh***	***1978***	***Electric power***
Hydro energy	40 x 10^3 GWh	3440	Electric power
Biomass and biogas	318 x 10^6 GJ	7591	Thermal energy Electric power
Geothermal energy	7 x 10^6 GJ	167	Thermal energy

Source: GD no. 1535/2003 - "Strategy for the Promotion of Renewable Sources of Energy"

It can be noticed the wind energy potential in energy power generation from renewable sources could reach a theoretical maximum of 13.4 %.

Table 2. ***The objectives, forecasts and achievements at national level for the use of renewable energy sources***

	Unit	2004	2005	2006	2007	2008	2010	2015	2020
The evolution of final consumption of energy									
Final consumption of energy	Thousand toe	25498	24768	24768	24022	25303	23056	25537	28507
Gross final consumption of energy	Thousand toe	27970	27041	27246	26486	27673	25246	27966	31212
Energy from RES	Thousand toe	4479	4921	4635	4658	5279	4807	5758	7491
Proportion of energy from RES in total	%	16.01	18.2	17.01	17.59	19.08	19.04	20.59	24

Source: Provisional document in the field of Energy from renewable sources, 2010 & GD no. 1535/2003 - "Strategy for the Promotion of Renewable Sources of Energy"

According to the Provisional document in the field of Energy from renewable sources, 2010, to properly fulfill the objective for the year 2020, Romania will have to use 63.5% of the total available potential of renewable energy sources. *** (2010)

Wind energy use is relatively recent in Romania. The trend and forecast for the installed capacity and electric power production is presented in table 3.

Table 3. ***Evolution on installed capacity and electric power production using wind energy***

	2005	2008	2010	2015	2020
Installed power capacity (MW)	1.320	5.222	560	3200	4000
Electricity Production (GWh)	0.227	4.978	460	6614	8400

Source: Provisional document in the field of Energy from renewable sources, 2010 & GD no. 1535/2003 - "Strategy for the Promotion of Renewable Sources of Energy"

2.2. Estimated GHG Emissions Reduction

Energy represents the most important sector in Romania in terms of GHG emissions. The Energy sector accounted for 66.7% of the total national GHG emissions in 2008 (without LULUCF).

Table 4. ***Greenhouse gas emissions from the energy sector***

Category ID	**Category name**	**Base year (1989)**	**2008**
1	1. Energy	188410.3	101991.4
1.A.1	1.A.1. Energy industries	106310.3	47584.8
1.A.2	1.A.2. Man. industries and construction	37551.0	18157.4
1.A.3	1.A.3. Transport	5815.1	14683.6
1.A.4	1.A.4. Other sectors	10540.8	10921.9
1.A.5	1.A.5. Other	NA. NE	NA. NE
1.B	1.B. Fugitive emissions	28193.1	10643.7

Source: UNFCCC Database

The GHG emissions from the energy sector decreased in 2008 with 45.87% compared with the base year.

To estimate the GHG emissions reduction in Romania as a result of the use of wind energy, there were calculated the emissions resulting from the combustion of equivalent quantities of fossil fuels (coal, natural gas, fuel oil), to obtain the same quantity of energy. The calculation of the significant GHG emissions (CO_2, CH_4 and N_2O), strictly for the fuels combustion process was developed based on 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Table 5. ***Evaluation of GHG emissions reduction by using Romania's potential of wind energy***

Wind energy	***Energy production***		***Sector***	***Thousand tones of $CO_{2\ equiv}$ replaced annually***		
	(GW h)	Thousand toe		**Lignite**	**Natural gas**	**Liquid fuels**
Annual theoretical potential of wind energy	23000	1978	Electric power	8332	4626	6059
2008 Electricity production	4.978	0.428	Electric power	1.8	1.00	1.31
2010 Forecast	460	39.56	Electric power	166.44	93	121
2015 Forecast	6614	568.8	Electric power	2396	1330	1742
2020 Forecast	8400	722.4	Electric power	3043	1689	2213
TOTAL GHG emissions reduction by using whole national energy potential of RES				***61717***	***34389***	***44930***
TOTAL GHG emissions reduction by energy from RES achieved in 2008				***22110***	***12337***	***16102***

These calculated values could be actually corrected in the sense of an additional reduction as a result of GHG emissions "saved" from the fossil fuels extraction, preparation and distribution.

It can be seen that the GHG emissions in 2008 where actually smaller with about 12 to 20% due to the use of SRE, but the share of wind energy was quite insignificant.

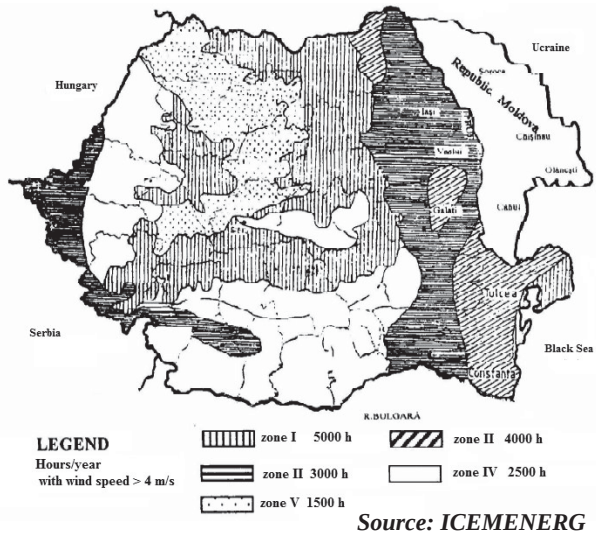
Even though the use of the entire national wind energy potential could determine a significant GHG emissions reduction, the technology, infrastructure and environmental restrictions limits wind energy valorization.

3. WIND FARM INVESTMENS

Because of its geographical position, Romania has a temperate to continental climate, also influenced by its varied topography. Accordingly, there have been delimited 5 wind areas, taking into account the wind energy potential 50 meters above ground and higher.

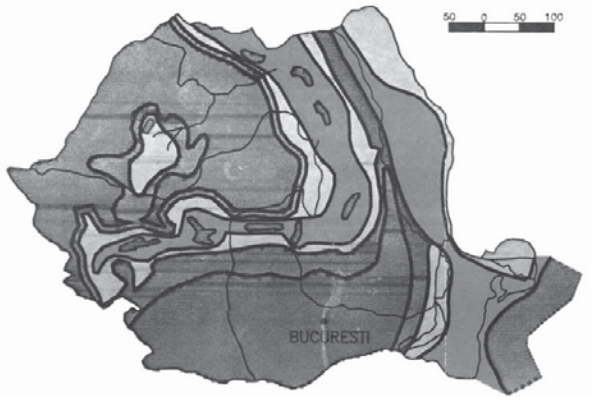
The wind maps presented in figure 1, show a generally high energy potential, especially along the Black Sea Coast (on-shore and off-shore) where the climate is mild, and in the alpine area where the climate is severe.

Despite this general favorable picture, the area available for wind farms location is actually smaller due to various limitations, imposed by environmental factors, especially the biodiversity concern and severe climate conditions.



Source: ICEMENERG

	High mountaines		open sea		coast		plaines		hills	
	m/s	w/mp	m/s	w/mp	m/s	w/mp	m/s	w/mp	m/s	w/mp
	>11.5	>1800	>9.0	>800	>8.5	>700	>7.5	>500	>6.0	>250
	10.0–11.5	1200–1800	8.0–9.0	600–800	7.0–8.5	400–700	6.5–7.5	300–500	5.0–6.0	150–250
	8.5–10.0	700–1200	7.0–8.0	400–600	6.0–7.0	250–400	5.5–6.5	200–300	4.5–5.0	100–150
	7.0–8.5	400–700	5.5–7.0	200–400	5.0–6.0	150–250	4.5–5.5	100–200	3.5–4.5	50–100
	<7.0	<400	<5.5	<200	<5.0	<150	<4.5	<100	<3.5	<50

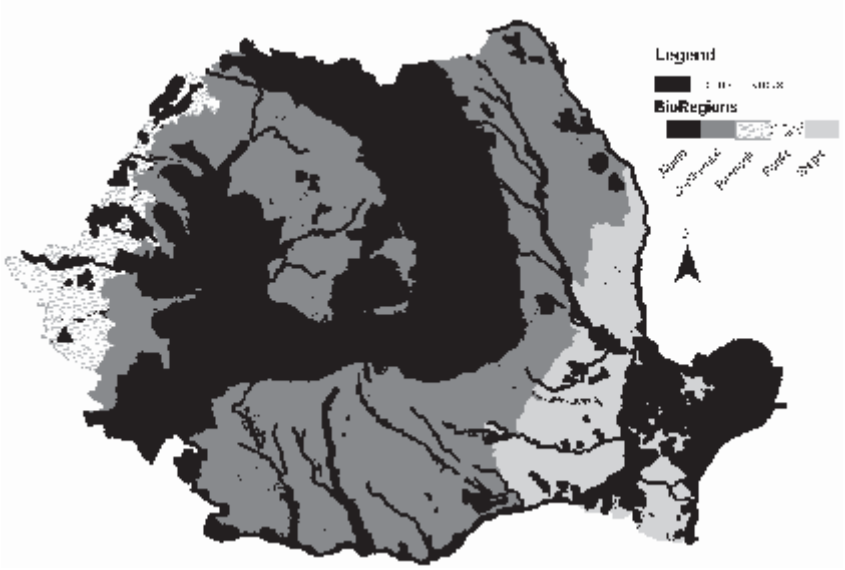


Source: http://www.unesco.pub.ro

Figure 1. ***Maps of wind potential in Romania***

Figure 2 illustrates the defined exclusion areas obtained by overlapping the thematic layers representing birds Special Protection Areas (SPA), Sites of Community Interest (SCI), national reservations, parks and the Carpathians Protection Convention limit, but also the bioregions and major rivers.

The alpine area was defined as an exclusion area due to its rough climate, with long periods of low temperature and icy conditions, and also difficult to reach. Also, the on-shore pontic bioregion is entirely covered by the SPA and SCI delimited by the environmental authority, as it offers favorable living conditions for wild flora and fauna. The banks of the major rivers are also proposed as exclusion areas as they are both wild life supporting and provide bird's orientation guidance and resting places during migrations.



Source of thematic layers: NEPA Biodiversity

Figure 2. ***Biogeographically exclusion areas***

Beyond the fact that the investments in wind farms seems to be financially attractive, the overview of the available locations is not updated with general exclusion areas related to military, aviation and communications buffered zone(s), and due to other existing or under authorization projects.

Also, the allowable/available options for the connection to the national electric network should be made available.

4. CONCLUSIONS

Romania has significant wind energy potential. Valorization of this potential would "save" the fossil fuels limited resources and would considerably reduce GHG emissions, contributing to the climate change mitigation efforts. Assuming the simplifying hypothesis that the wind potential energy would substitute an equivalent amount of energy generated by burning fossil fuels, there were calculated the potential savings of GES emissions based on the IPCC 2006 methodology.

From the environmental point of view, there are not clear provisions concerning the wind-farms allowable locations. A map of exclusion areas was drawn by overlapping the layers corresponding to Natura 2000 areas, parks and reservations, but also taking into account the major river courses as wild life supporting. Additional exclusion areas are needed to draw the overall available locations. Systemising and updating the information on environmental constraints and changes occurring in the infrastructure can improve investors' guidance on the overview of available locating zones.

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Acknowledgments

This work was co-financed from the European Social Fund through Sectoral Operational Programme Human Resources Development 2007-2013. Project number POSDRU/107/1.5/S/77213 „Ph.D. for a career in interdisciplinary economic research at the European standards" (DOCCENT).